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Childrens' left turning preference is not modulated by magical ideation

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Abstract

The literature on human turning preferences is inconsistent. While the few studies with children below 14 years of age uniformly describe an overall left-turning (counterclockwise) tendency, a recent internet study with more than 1500 adults found a right-sided (clockwise) bias. We set out to investigate spontaneous turning behavior in children age 5 to 13 years and, based on neuropsychiatric work in adults, also explored a potential association with magical thinking. Findings indicated a clear left-turning preference, independent of a participant's sex and handedness. Whether a child responded a question about the existence of extrasensory communication in the affirmative or not was unrelated to direction and size of turning bias and lateral preference. Our results are consistent with a left-sided turning preference reported for children, but in opposition to the clockwise bias recently described in a largescale study with adults. Whether they point to a maturational gradient in the preferred direction of spontaneous whole-body rotation or rather to a lack of comparability between measures used in observational vs. internet-based studies remains to be further investigated. Regarding a purported association between body turns and magical thinking, our study is preliminary, as only one single question was used to probe the latter.

Key words: Turning behavior; lateral biases; developmental neuropsychology; motor system; neuropsychiatry

Introduction

It is common wisdom among explorers and military troops that human beings propagate in circles or spirals once they move without landmark orientation and with no opportunity to use a compass (McManus, Nicholls, & Vallortigara, 2010). These "spiral movements" during locomotion enjoy a long-standing and enduring interest in laterality research (Schaeffer, 1928). The issue of whether, on the population level, they occur more in a clockwise (rightward) or in a counterclockwise (left-ward) direction has been a matter of considerable debate. Some authors observed a preponderance of left-circling behavior (Schaeffer, 1928), others reported a tendency to circle or turn to the right (Mead & Hampson, 1996, 1997; Stochl & Croudace, 2013), still others were unable to discern a reliable preference in either direction (Souman, Frissen, Sreenivasa, & Ernst, 2009). While the assumption that handedness, or rather "sidedness" (Lombroso, 1903), may be a predictor of turning asymmetry was repeatedly entertained, the existing findings are inconclusive. Early investigators did not find an association (Schaeffer, 1928), but a recent internet survey with more than 1500 respondents found both handedness and footedness to be good predictors of turning preferences (Stochl & Croudace, 2013). Other studies have reported contradictory findings: turning direction ipsilateral to lateral preference (Scharine & McBeath, 2002); contralateral (Mohr, Landis, Bracha, & Brugger, 2003a; Yazgan, Leckman, & Wexler, 1996); ipsilateral for men but contralateral for women (Bracha, Seitz, Otemaa, & Glick, 1987); footedness and eyedness, but not handedness predict turning direction (Previc & Saucedo, 1992).

More consistency comes from work on individual differences other than lateral preferences in the motor system. One of the early studies described a left turning and veering bias for the „lower races“, lunatics as well as for women and children, because "evolution goes from the preeminence of the right hemisphere to one of the left" (Delaunay, 1883, p. 971). While these reports smack of a Zeitgeist that regarded the right hemisphere as representing a most degenerated style of thinking (Harrington, 1995; McGilchrist, 2009); more recent work on associations of left-ward circling with a right hemisphere "functional preeminence" in the course of psychiatric disorders may have some justification. For instance, Bracha and collaborators found a correlation between the severity of psychiatric patients' productive symptoms of schizophrenia and the extent to which they turned to the left during daily activities (Bracha, Livingston, Clothier, Linington, & Karson, 1993). This finding, along with comparable left-sided preferences obtained in a laboratory situation (Harvey, Nelson, Haller, & Early, 1993), was interpreted as the consequence of a hyperdopaminergic state of the right hemisphere (Bracha, 1989). Specifically, it was argued that both, the emergence of psychotic thought and a neglect to the right side of space (manifesting in exaggerated left-turning) may be caused by an asymmetry in the mesolimbic dopamine system. This pharmacopsychological hypothesis was based on previous empirical data in patients with hemi-Parkinson and in animals (mostly rodents) with unilateral lesions affecting the dopamine turnover in one cerebral hemisphere (both patients and animals turning ipsilaterally to the hemisphere with less dopamine; Bracha, Shults, Glick, & Kleinman, 1987; Glick, Weaver, & Meibach, 1981; Patino, Garcia-Munoz, & Freed, 1995). In healthy persons, "schizotypy" denotes a style of perception and action reminiscent of that known from schizophrenia. Accordingly, a schizotypal personality style has also been associated with a hyperattention towards the left side of space (Brugger & Graves, 1997), in particular also with an exaggerated left-turning bias (Mohr, Bracha, & Brugger, 2003b). Even mild forms of schizotypy appear to be related to a left-sided orientation bias, arguably due to a relative hemi-hyperdopaminergia as suggested by Bracha (1989). Thus, according to Taylor, Zäch, and Brugger (2002), subtle signs of "magical ideation", thought to be a cardinal symptom of schizotypy (Eckblad & Chapman, 1983), are accompanied by left-sided attentional asymmetries because of a common responsibility of the right cerebral hemisphere for (1) indirect and remote associations characteristic of the formation of ideas of reference and (2) an attentional orienting towards the left side of space (Taylor et. al., 2002). According to this notion, signs of schizotypy and hemispatial inattention are not indicative of right hemisphere damage, but on the contrary of an overcompensation of a developmentally early left hemisphere impairment.

With respect to development, we note a remarkable paucity of studies on turning preferences in children. To our knowledge, only four author groups have studied whole-body rotation behavior (“global rotations”, in the terminology used by Stochl & Croudace, 2012) in children younger than 14 years old. They all described a consistent left-turning bias, for the age ranges 7 to 13 years (Günes & Nalçaci, 2006: $N = 31$), 6 to 9 years (Gospe, Mora, & Glick, 1990: $N = 56$), 3 to 6 years (Day & Day, 1997: $N = 67$) and a mean age of 9.5 years (Golomer, Rosey, Dizac, Mertz, & Fagard, 2009: $N = 45$). The last-mentioned author group reported that the left-ward turning preference of dance-naïve children shifted to a right-ward preference in professional young dance students (mean age = 11.9 ± 1.1years; $N = 36$). One more study investigated circling behavior (spinning around) in children with autism (Bracha, Livingston, Dykman, Edwards, & Adam, 1995) and found a significant left-ward bias, which was absent, however, in the control group of 27 healthy elementary school children (average age of 6 years). In the present study we aimed to further explore turning bias in a large sample of children, both girls and boys. Should the previous findings of a left-turning preference be confirmed, an explanation of the discrepancy between the results with children (left turning) and those with adults (Stochl &

Croudace, 2013; right turning) would seem desirable. Some confusion might arise by the terms “turning”, “circling” and “rotation behavior”. Stochl & Croudace (2013) give precise definitions: a rotation indicates a partial or full spinning movement around the axial axis of one’s body. By “turning” these authors mean “deviations from a straight line when moving” (p. 2), a bahavior termed “veering” by other authors (e.g. Mohr et al., 2003b). Finally, “circling” would refer to a turning behavior in which at least one full “whole circle” would be completed around an external central point. Below we will stick to the term “turning”, despite the fact that “half-circling” would be the correct term to choose according to the suggestions by Stochl & Croudace (2013): we relied on everyday language to describe the “half-circling” observed when somebody runs towards a pole, turns around it and runs back to the start position (see also Lenoir et al., 2006).

A novel aspect of the present study was the analysis of turning direction as a function of the child's "magical thinking". We have recently complained about the absence of work on the cognitive-neuropsychological correlates of the infant magical mind (Brugger & Mohr, 2008), and the study reported here presents a preliminary step towards filling this gap. It is preliminary especially in view that, for reasons of time, “magical thinking” could only be assessed with one single question. We hypothesized (1) an overall preference for turning in a counterclockwise direction that (2) would decrease with increasing age (as supposed by Delaunay, 1881) and (3) would be especially pronounced in those children, who believed in a magical form of causation (Mohr et al., 2003b).

Methods:

Participants

A total of 222 children, 113 boys and 109 girls, took part in the study, which had been approved by the local Ethics committee of the Department of Neurology of the University Hospital Zurich. They were recruited from a local Kindergarten and school. All children were neurologically and psychiatrically healthy to the best of their teacher's knowledge and their age ranged from 5 to 13 years (M = 8.6 yrs, SD = 2.0 yrs), girls and boys having a comparable age (t = 0.98, p > 0.32, two-tailed).

Hand preference assessment

Hand preference was assessed prior to the turning behavior test by observing the child play five trials of the game *Memory* (also known as *Pelmanism*, see http://www.pagat.com/misc/pelmanism.html; last accessed Nov.

13, 2015). 20 picture cards were placed face-down on a table, and the participants were required to turn around five cards (one card at a time, five times in a row) "to see whether a match could be obtained". Turning of the cards could be achieved at one's preferred pace, and it was made explicit that only one hand should be used for one trial, of which the child knew in advance that there would be five. The variable "hand preference" was determined according the protocolled number of times the left hand was used to turn the cards (0-1: "right-hand preference", 2-3: "no preference", 4-5: "left-hand preference"). We preferred to determine hand preference implicitly by observing it during a task, as understanding questions about hand use could have been problematic by young children and responses prone to biases because of left-handedness being associated with a minority trait.

The experiment was set-up in a corridor (width 2.5 m), and turning behavior was assessed by duplicating the procedure employed by Lenoir et al. (2006) with adolescents (Lenoir, Van Overschelde, De Rycke, & Musch, 2006) because of its playful character. Immediately behind the table with the Memory cards for the assessment of hand preference there was a starting line marked on the floor. In a distance of 10 m, a colored pole was placed exactly in the middle of the corridor. It was the child's task to "run just beyond the post, turn around it and return to the table". It was emphasized that this was not a race, but that the task should be performed at one's most comfortable running speed. At least three trials had to be taken. For each trial the direction of turning around the post was noted without the child's knowledge. As some participants insisted to take more than three trials, a variable "percent turning direction" was computed that reflected the percentage of counterclockwise turns (leftturns) of the total accomplished number of trials (minimum of 3, maximum of 6 trials). Testing took place during a gym lesson, and each child was tested individually. It was ensured that observation of any other participant's turning behavior was impossible.

Assessment of perceptual pseudoneglect and magical ideation

Immediately after the turning behavior assessment, the child returned to the table and was shown two chimeric faces, one on top of the other. In half of the subjects, the top face was a happy/sad composite, in the other a sad/happy composite. Participants had to indicate, "which face looked just a bit more happy", responding by "the top face" or "the bottom face". It was recorded whether the child chose the face with the smile on the left ("left preference") or the one with the smile on the right ("right preference"). Free-viewing chimeric faces tasks are regularly used to assess perceptual pseudoneglect (see the meta-analysis by Voyer et al., 2012). As a final question, each participant was asked "Do you believe that your mother can feel at a distance (e.g. when being at home) when you feel bad in school/Kindergarten or when you get homesick in a camp or far away?" This question was used as most questionnaires about schizotypy contain at least one item asking for belief in telepathy. Children were classified as entertaining magical beliefs if they responded in the affirmative.

Results

Turning Behavior

Overall, there was a significant preference for counterclockwise turning (*mean percentage* ± *standard deviation (SD)*: 78.5 ± 37.9%; significantly different from 50.0% by a one-sample t-test: $t = 30.9$, $p < .001$), the 109 girls (*mean percentage* ± *SD*: 75.8 ± 40.1%) and the 113 boys (mean percentage ± *SD* = 81.1 ± 35.5%) displaying comparable preferences ($t = 1.0$, $p = .30$). There was no significant difference in turning behavior between age groups (5-8 years: mean percentage ± *SD* = 79.21 ± 36.65; 9-13 years: *mean percentage* ± *SD* = 77.75 ± 39.11; $t = -.29$, $p = .78$). Of the 222 participants, 166 showed a right-hand preference in the Memory game, 23 a left-hand preference and 33 showed no hand preference (respective figures for girls: 81, 13, 15; for boys: 84, 10, 19). A two-way ANOVA (factors *Gender* and *Hand Preference*) of the percentage of turning preference (see Figure 1) revealed no main effect of *Gender* ($F(df=1) = .04$, $p = .84$), no main effect of *Hand Preference* ($F(df=2) = .03$, $p = .98$) and no interaction ($F(df=2) = .32$, $p = .73$).

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insert Figure 1 about here

Neither for the sample as a whole nor for girls and boys separately was there a significant correlation between age and the raw scores in the hand preference task ($r \leq .08$, $p \geq .47$) or the percentage left turning ($|r| \leq .14$, $p \geq .54$). Likewise, handedness and left turning were not significantly correlated with one another ($r = -.04$, $p = .52$ for the whole sample, $r = -.01$, $p = .95$ for the 109 girls, $r = -.09$, $p = .36$ for the 113 boys).

Magical Ideation

144 participants responded "yes" to the question on magical ideation (77 girls, 67 boys). Table 1 displays the respective percentages for two different age groups and the sample as a whole.

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insert Table 1 about here

There was neither a significant difference between the different age groups ($\chi 2$ = 0.69, *p* = .79) nor for the handedness groups ($\chi 2$ = 3.52, *p* = .61), but a non-significant tendency for girls to answer "yes" to the magical ideation question more frequently than boys ($\chi 2$ = 3.51, *p* = .06). Table 2 shows the mean percentages of left-turning as a function of participants' magical ideation. Unpaired t-tests revealed no significant differences in turning preferences between the two groups of magical ideation (*t* = -.87, *p* = .39 for the overall sample; *t* = .97, *p* = .34 for boys; *t* = .07, *p* = .94 for girls). Only for the sample from 9 to 13 years of age, collapsed over both gender groups, there was a significant association between turning preference and magical ideation (*t* = -2.72, *p* =.01); contrary to our general prediction, the magical children of this age group turned *less* to the left (*mean percentage* ± *SD* = 71.3 ± 42.7%) than the non-magical children (89.4%, *SD* = 28.6%).

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insert Table 2 about here

Perceptual pseudoneglect (Chimeric Faces trial)

There was no side preference in choosing the face with the smile on the left ("left preference") or the one with the smile on the right. Of 222 participants 112 (50.5%) showed a preference for the left-smiling face in the chimeric faces trial (57 girls, 55 boys). Table 2 displays the respective percentages for different ages. There was neither a significant difference between girls and boys ($\chi 2$ =.29, *p* = .59) nor any difference in the choice of a particular half-face between the different age groups ($\chi 2$ = 2.58, *p* = .11). There was no association between side preferences in the chimeric faces trial and magical ideation for the whole sample ($\chi 2$ = 3.12, *p* = .08), nor within girls ($\chi 2$ = 4.9, *p* = .49) or boys ($\chi 2$ = 3.12, *p* = .08) of any age range (5-8 years: $\chi 2$ = 1.24, *p* = .27; 9-13 years: $\chi 2$ = 1.56, *p* = .21). Finally, there was no association between side preferences in the chimeric faces trial and turning behavior (*t* = 0.38, *p* = .74 for the whole group, $t \leq 0.4$, $p \geq .66$ for the different age and gender groups separately).

Discussion

The present study set out to investigate spontaneous turning behavior in young children and its possible relationships with handedness, lateral orienting bias and magical ideation. To this end, 222 children from age 5 to 13 years were required to perform a turning task, to use one hand in a short card game, to choose among two chimeric faces and to indicate whether they believed in some sort of extrasensory information transfer. We found a clear preference for turning in a counterclockwise (left-ward) direction for the total sample as well for different subgroups. Overall, the left-turning bias we measured was more pronounced than that previously described in work with comparable age groups (Day & Day, 1997; Gospe et al., 1990; Gunes & Nalcaci, 2006). Previous findings of a more asymmetric turning behavior in boys than in girls by Gunes and Nalcaci (2006) could only be observed as a weak tendency (mean percentage of turning behavior in boys of 81.1 versus 75.8 in girls). We note, however, that from the four publications we are aware of on rotation behavior in healthy children, the one by Gunes and Nalcaci is the only to report a gender effect; both Gospe et al. (1990) and Day & Day (1997) explicitly reported an absence of any gender differences, and Golomer et al. (2009) had only tested girls. In any case, the higher turning rates in boys compared to girls (Gunes & Nalcaci, 2006) appears to be inverted in the adult population, in which more pronounced turning biases were reported for women than men (Bracha et al., 1987; Stochl & Croudace, 2013). The last authors' explanation for this gender effect is in terms of women's menstrual cycle, which is known to modulate dopaminergic asymmetries and whose absence in our pre-pubertal sample might be related to the absence of gender effects.

In our experiment, age was unrelated to a child's preferred rotation behavior, which makes a gradual maturation factor, assumed by both Delaunay (1883) and Gospe et al., (1990) improbable. The so far largest study on human turning and rotation behavior (Stochl & Croudace, 2012: $N = 1526$, age range 11 to 80 years) did not investigate age as a potentially predicting factor of rotation preference. Thus, little is known about this variable in the literature on human turning preferences, especially during the years of maturation. We can only speculate about the discontinuity of a left-turning preference in children age 14 years and younger and the adult right-turning preference reported by Stochl and Croudace (2012). One possibility is a maturational gradient of those plurimodal parieto-temporal regions arguably critical for lateralized orientation in space and reportedly showing a right-hemisphere dominance in the early years of life (Chiron et al., 1997). Alternatively, the measure used to assess turning direction in Stochl and Croudace's internet study may not be comparable with that used in behavioral work with children. In the latter, turning preference was based on the observation of a child's spontaneously chosen direction in playful real-life situations and without the individual knowing the critical variable. In the web-based assessments (Stochl and Croudace, 2012) participants were asked to either imagine spontaneous body turns or to stand up, turn their back on the computer screen and then indicate the direction of turning. It is possible, if not highly probable, that this latter measurement is based on much less spatial involvement than the observational measures used with playing children.

We found the preference for the side of turning independent of a child's handedness. This is in accordance with the prominent finding in the literature on children's turning biases (Golomer et al., 2009; for girls), but in contrast to the majority of findings in the adult literature (Bracha et al., 1987; Mohr et al., 2003a; Previc & Saucedo, 1992; Scharine & McBeath, 2002; Stochl & Croudace, 2013; Taylor, Strike, & Dabnichki, 2007; Yazgan et al., 1996). As noted in the Introduction section, however, the relationship between sidedness and turning biases is not as simple as one might wish. Some of the above-cited studies described turning preferences ipsilateral, some other contralateral to the side of dominant motor or sensory function. Still others found complex interactions between a participant's sex and the direction of the correlation between measures of conventional lateral preferences and those of turning (e.g. Bracha et al., 1987). Our null finding with respect to the influence of childrens' handedness on turning direction (see Schaeffer, 1928, for a similar finding in adults) cannot be explained by assuming that no clear hand preference would have been established by the participants of our sample; motor preferences in hand use can be demonstrated at ages below that of our youngest participant (Michel, 1998) and arguably already during the fetal state (McCartney & Hepper, 1999). We failed to assess a child's footedness, but note that this lateral preference measure is rarely a better predictor of turning behavior than is handedness (Stochl & Croudace, 2013; for an exception see Previc & Saucedo, 1992). Likewise, our failure to find a significant "pseudoneglect", i.e. a spatial orientation bias towards the right side of the body, should have been measurable even in our age group (Brooks, Della Sala, & Logie, 2011; Goksun et al., 2013), had we used more than just one trial of a choice between two chimeric figures. Unfortunately, the lack of a correlation between participants' performance on this task and the other variables cannot be reasonably interpreted in view of this methodological shortcoming. Quite generally, the absence of any statistical relations in the present study may have arisen by failing to use latent variable modelling and to correspondingly assess the different latent asymmetry variables with multi-item tools (see Tran & Voracek, 2015 for a recent application in laterality research).

A final remark should be devoted to the discussion of a clear absence of a relationship between preferred turning bias and "magical ideation". Previous research with adults has shown associations between the propensity to believe in "magical" or scientifically unsubstantiated phenomena and handedness (Barnett and Corballis, 2002; see Badzakova-Trajkov, Haberling, & Corballis, 2011 for a critique), lateral orientation bias and, most specifically, with rotation behavior (Brugger, 2007). Irrespective of age, roughly 65% of our participants responded “yes” to a question asking for their mother being able to “feel” their mind’s state at a distance. Girls (71%) were slightly more inclined to believe in such an ability than were boys (60%), mirroring gender differences in paranormal belief in the adult population, both at large (Mohr et al., 2003b) and in some mixed-sex studies (Lindeman, Svedholm-Hakkinen, & Lipsanen, 2015), but not in others (e.g. Vitulli, Tipton, & Rowe, 1999). Several possibilities need to be considered in view of our failure to establish a statistical relationship. While one could jump to the conclusion that the belief in magical forms of causation does not have a neuropsychological basis at all, this seem unlikely because the concept of magical ideation as an indicator of schizotypy (Eckblad and Chapman, 1983) builds on the concept of schizophrenia, and it is long considered an established fact that schizophrenia has a neural basis (Bakhshi & Chance, 2015). Also, while some studies on magical ideation using questionnaire measures of laterality have interpreted the associations they found as a response bias (e.g., Grimshaw et al., 2008), studies with lateralized lexical decision tasks (e.g. Brugger et al., 1993; Leonhard and Brugger, 1998) or hemispatial exploration paradigms (Brugger and Graves, 1997) cannot easily be dismissed on this ground. It may thus be allowed to consider possible alternative reasons for our failure to find a relationship between laterality measures and childhood magical belief.

First, our measure of rotation behavior may not have been optimally chosen. This is unlikely a reason for our null finding, however. We have adopted the measure and procedures from Lenoir et al. (2006), who themselves borrowed these from similar previous research and successfully demonstrated significant (left) turning behavior in their adult population. We admit that the number of trials administered to participants may have been too small (between three and six). Future studies may rather focus on turning bias in natural environments, which have previously proved successful with adult participants (e.g. Mohr, Thut, Landis, & Brugger, 2003c) and whose long term assessment has made technical progress over the past decade (Leuenberger, Hofmann, Brugger, & Gassert, 2015). Second, our assessment of magical belief was certainly far from ideal. While the type of belief we inquired is prototypical for magical ideation (Eckblad & Chapman, 1983) and part of virtually all schizotypy scales in use for adolescents and adults, the use of just one item to assess belief might admittedly be one of the major shortcomings of the present study. Prospective investigations of a potential association between turning behavior and magical beliefs in children should use validated scales with more than just one question. An example is the 30- item inventory introduced by Bolton, Dearsley, Madronal-Luque, and Baron-Cohen (2002) which was successfully used by Krummenacher et al. (2014) in a lateralized placebo analgesia experiment with children 6 to 9 years. Third, provided the measures used are valid, our findings may just indicate that there actually *is* no relationship between infant turning behavior and magical beliefs (without denying the possibility of neuropsychological correlates of *adult* magical beliefs). We cannot exclude this certainly parsimonious explanation. However, we point out that there is indeed an only moderate continuity of personality functioning from childhood to adolescence and adulthood (Bolton et al., 2002; Krummenacher et al., 2014). Thus, hypotheses about child behavior derived from observations in adults must be met with caution, especially when facing the difficulties of assessing schizotypal traits in children and the concomitant lack of appropriate instruments (Caspi, Roberts, & Shiner, 2005; Esterberg, Goulding, & Walker, 2010). To our knowledge, there are no direct data on the purported dopamine regulation of children's rotation behavior nor is there evidence that the magical world of children would rest on brain dopaminergic asymmetries similar to those proposed for human adults on the basis of empirical findings (Ericson, Tuvblad, Raine, Young-Wolff, & Baker, 2011). Unfortunately, while the psychology of magical thinking in children is of broad interest to various subfields of psychology (see, for instance, the autoritative volume of Rosengreen, Johnson, & Harris, 2000), there is a remarkable lack of *neuro*psychological approaches. What the Italian neurologist Eduardo Bisiach stated some 25 years ago for investigations of the adult human mind is evidently still valid for child neuropsychology: "Nothing appears more remote from the current frontiers of neuroscience than the circuits underlying the fixation and mutation of human beliefs" (Bisiach, Rusconi, & Vallar, 1991, p. 1029).

To conclude, a direct comparison of children and adults' magical beliefs and their neuropsychological correlates still awaits investigation. Prospective studies, preferably with samples of a large age range and including validated instruments for belief assessment, would appear vital for both neuropsychiatry and developmental psychology.

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Figure Legends

Figure 1:

Mean preference for left-turning (counterclockwise direction) as a function of handedness for boys (N = 113) and girls (N = 109) separately. Note that the x-axis represents 50%, i.e. no directional turning preference. Error bars represent standard errors of the mean. Left-turning was highly significant for all handedness groups, for both girls ($t(df=108)$ = 6.7, p < .0001) and boys ($t(df=112)$ = 9.3, p < .0001).

Table 1:

Percentages of left-side preference in the one-trial chimeric faces task and of affirmative response to the magical ideation question as a function of participants' age and gender.

number of participants:		N	% "yes" to magical ideation question:	% left-preference for chimeric faces:
age in years:				
ages 5	girls	58*	70.2	44.8
to 8	boys	49	61.2	44.9
	all	**107**	**65.4**	**44.9**
ages 9	girls	51	72.5	60.8
to 13	boys	64	57.8	51.6
	all	**115**	**64.3**	**55.7**
over	girls*	109	70.6	52.3
all ages	boys	113	59.3	48.7
	all	**222**	**64.9**	**50.5**

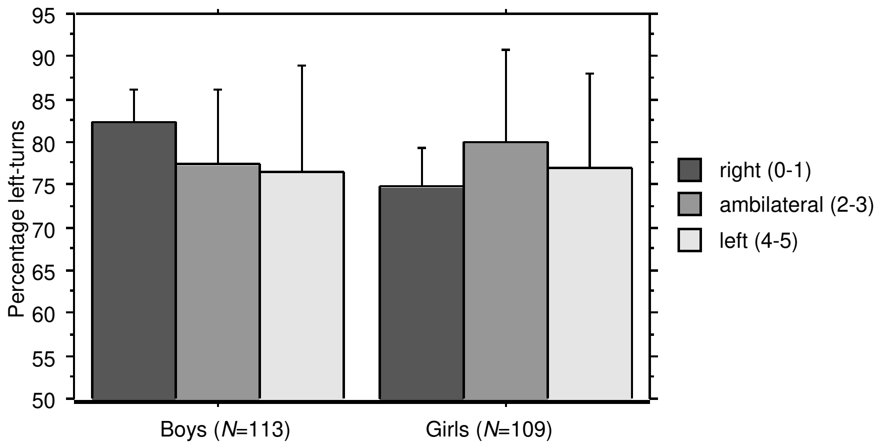
* one girl could not decide whether she should respond "yes" or "no" to the magical question

Table 2:

Mean percentage left-turning as a function of magical ideation. Data are shown for two different age groups and girls and boys separately.

		Left turning preferences	
Participants		"yes" to MI question	"no" to MI question
ages 5 to 8 years:			
	girls (n = 57)	80 ± 36.83	73.53 ± 43.72
	boys (n = 49)	85.83 ± 34.54	71.06 ± 33.87
	all (n = 106)	82.5 ± 35.73	72.23 ± 38.29
ages 9 to 13 years:			
	girls (n = 51)	65.77 ± 44.91	91.07±27.05
	boys (n = 64)	76.8 ± 40.16	88.58 ± 29.88
	all (n = 115)	71.28 ± 42.67	89.4 ± 28.63
all			
	girls (n = 51)	73.16 ± 41.26	81.45±37.62
	boys (n = 64)	80.5 ± 37.75	81.34 ± 32.42
	all (n = 115)	76.74 ± 39.71	81.39 ± 34.37

Figure 1:


95
90
85
80
75
70
65
60
55
50
Percentage left-turns
Boys (N=113)
Girls (N=109)
right (0-1)
ambilateral (2-3)
left (4-5)